






The Effectiveness of Training on Auscultation of Heart with a Simulator of Cardiology in Medical Students

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Abstract

AIM: The purpose of this study was to determine whether the training module with a simulator of cardiology improves auscultation skills in medical students.

METHODS: Medical students of the 3rd year after completing the module of the cardiovascular system of the discipline "Propedeutics of internal diseases," passed a 2 h or 4 h training module in clinical auscultation with retesting immediately after the intervention and in the 4th year. The control group consisted of the 4th year medical students who had no intervention.

RESULTS: The diagnostic accuracy in 2 h training was 45.9% versus 35.3% in 4 h training, $p < 0.001$. The use of a cardiosimulator significantly increased the accurate detection of mitral regurgitation immediately after training on a simulator (more than 73%), $p < 0.001$. The next academic year, regression was observed in the diagnostic accuracy of mitral insufficiency in the intervention group after 6 months of observation by 4%. The auscultation skills of students at the bedside of real patients did not increase after training on a simulator: The accuracy of diagnosis of the auscultatory picture of the defect was equally low in the intervention group and the control group (35.0% vs. 30.8%, $p = 0.651$).

CONCLUSION: Two hours training was more effective than 4 h training. After training on cardiac auscultation using a patient's cardiological simulator, the accuracy rate was low in a situation close to the clinical conditions and in a clinic on a real patient.

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Introduction

Auscultation of the heart is one of the important skills of physical examination of patients in the diagnosis of various heart diseases. Simulation has been identified as a potential way to improve physical examination methods in medical education [1].

Despite many years of experience using cardiac simulators in medical education, the data are contradictory in numerous studies on simulation training. There are studies which show some improvement in heart auscultation skills among medical students after using a cardiopulmonary simulator [2], [3]. A meta-analysis of 13 comparative studies showed that simulation-based learning with auscultation of the heart was effective [4]. The heart auscultation curriculum, consisting of a computer textbook and a heart disease simulator, improved auscultation skills in trained

students compared to untrained ones [5]. The use of the Kyoto-Kagaku K Plus simulator in training improved Student's t-test auscultation skills in a Bernardi *et al.* study [6]. In other studies, weak cardiological examination skills were recorded in medical students using cardiac simulators [7], [8], computer training programs [9], and at the patient's bedside [10], [11]. In several well-planned randomized trials, no significant differences were found between heart simulations and other interventions [12], [13], [14], [15].

Thus, it remains unclear whether there is any intervention that can be applied at an early stage of medical training, contributing to the improvement of heart auscultation skills.

There were no studies conducted at medical universities of the Republic of Kazakhstan aimed at studying the effectiveness of simulation training, its place in educational programs, the selection of specific

teaching and assessment methods, and the necessary time to develop one or another skill.

Purposes

The purpose of the study was determining whether the cardiosimulation training improves auscultation skills in the 3rd year students of West Kazakhstan Medical University (WKMU).

Materials and Methods

Participants and simulators

A total of one hundred and fifteen 3rd year students of the general medicine faculty (77 students in a 2 h course and 38 students in a 4 h course of study) WKMU took part in a heart auscultation training using a heart disease simulator (KAF990, China). Ethical approval was obtained from the Local Ethics Committee of WKMU.

The training consisted of 2 h and 4 h practical classes (one academic hour is 50 min) in compliance with standard procedures (the presence of a dressing gown and a phonendoscope), including safety measures. Students were divided into groups of 6–8 people. Each group visited the practical skills center of WKMU for auscultation of the heart. The training was held in the 6th semester of the 2018–2019 academic year after passing the module of the cardiovascular system of the discipline “Propedeutics of internal diseases.” Simulation training at our university is not included in the compulsory educational program. The study involved students who agreed to additional training. The study was carried out as part of a grant of an intrauniversity research project “Research substantiation of the effectiveness of simulation training in the clinical disciplines of a medical university and its integration into educational programs.” Two certified teachers conducted heart auscultation training. After a short introduction, the teacher gave a minilecture on heart auscultation skills, heart sounds, including acquired heart murmurs with four heart defects (aortic valve stenosis [AS], mitral valve stenosis [MS], aortic insufficiency [AI], and mitral insufficiency [MI]).

Each student practiced on the simulator after mini-lecture led by the teacher. The KAF 990 simulator is a human torso dummy with four small built-in speakers in the aorta, pulmonary, tricuspid, and mitral valves. It provides 82 variations of heart sounds and sounds. Students used a conventional phonendoscope for the KAF 990 simulator.

Each student passed three different auscultation tests using the simulator after practicing to recognize heart sounds and heart sounds using the KAF

990 simulator. Students were informed that the grades received in the framework of this training will not have any relation to the overall performance of the course. All the students agreed to participate in the study. Vices were divided into two categories: “Insufficiency” (MI and AI) and “Stenosis” (MS and AS). The first test consisted of two parts. Students were informed that the vices were from the appropriate category. (1) Students listened to two vices from the “Insufficiency” category at random, tried to identify each of the two, and wrote down their answers; (2) students listened to two heart defects from the “Stenosis” category in random order and tried to identify an auscultatory picture of the disease. Immediately after the first test, the teacher conducted a debriefing, where he gave students feedback so that they could confirm which heart sounds or murmurs inherent in a particular defect they correctly identified and which ones did not, before proceeding to the second test.

The second and third tests, students were not informed about the category, listened and tried to identify each of the four defects in a random order, and wrote down their answers. Immediately after the second and third tests, the teacher also gave feedback to students.

At the 7th semester of the 2019–2020 academic year, the second stage of research was conducted – a controlled study on a real patient. The 4th-year medical students ($n = 18$ out of 77) who participated in 2 h simulation training in the 3rd year (main group) and students ($n = 19$) who did not go through training (control group) examined a real patient with mitral regurgitation. Students presented their results to an examiner, who then assessed heart auscultation skills. The expert was a practicing cardiologist who studied and verified the clinical data in a patient. Each student was tested on the same patient and evaluated by the same examiner, which means a higher degree of consistency and objectivity in the assessment.

Statistical analysis

Data were analyzed using the program Statistica 10 (Stat Soft, USA).

- (1) Comparison of the accuracy of determination of each of the four heart defects in the first, second, and third tests in the group of 2 h training on a simulator using the McNemar criterion χ^2 . $p < 0.05$ was considered statistically significant.
- (2) Comparison of the accuracy of determination of each of the four heart defects in the first, second, and third tests in the 4 h training group on a simulator using McNemar criterion χ^2 . $p < 0.05$ was considered statistically significant.
- (3) Comparison of the accuracy of determination of each of the four heart defects in the first, second, and third tests in the 2 h group and

- in the 4 h group on a simulator using the Pearson χ^2 criterion. $p < 0.05$ was considered statistically significant.
- (4) Comparison of the accuracy of determining heart disease in a real patient in the intervention group (training on the simulator) with the control group (without training on the simulator) using the Pearson χ^2 criterion. $p < 0.05$ was considered statistically significant.

Results

Diagnostic accuracy in three tests in a 2 h training is presented in Figure 1.

The overall accuracy in the 2 h training was 43.3% in the first test, 44.8% in the second, and 49.5% in the third test, the difference was statistically insignificant ($p = 0.4425$).

As can be seen from the data presented, most accurately the students in the third test determined the MI. Hence, if only 26 students out of 77 correctly identified this defect in the first and second tests, then in the third test, there are already 60 students ($p = 0.00001$) (Figure 1).

In the first test with informing, AI was correctly identified by 59 out of 77 students, then in the third test, only 30 students were already identified (76.6% vs. 44.1%, $p = 0.02064$), that is, 19 students, when they were not told the category, could not determine this defect (Figure 1).

If 56 of 77 students (73.7%) were incorrectly determined in the first test, the MS showed a decrease in the number of incorrect answers to 61% ($p = 0.00002$) (Figure 1).

As for AS, in the first test, 28 out of 77 students correctly identified this defect, while in the second attempt, 52 students (67.5%) identified it, but in the third test, there was a statistically significant decrease in accuracy to 36.4% ($p = 0.00019$) (Figure 1).

The overall accuracy in the 4 h training was 34.9% in the first test, 38.15% in the second, and 32.9% in the third test, the difference was statistically insignificant ($p = 0.861$).

Diagnostic accuracy in three tests in a 4 h training is presented in Figure 2.

The highest diagnostic accuracy in the 4 h training was among students of MI. Hence, if in the first and second tests, 14 out of 38 students were able to correctly identify this defect, then in the third test, already 28 students managed to determine the auscultatory picture inherent in MI ($p = 0.00933$) (Figure 2).

The accuracy of auscultatory diagnosis of AI of students statistically significantly decreased by 36.9% in the third test compared to the first test ($p = 0.00112$), but increased 2 times in comparison with the second (Figure 2). There was also a marked statistically significant decrease in the percentage of students' correct answers when determining AS between the 2nd and 3rd tests (65.8% vs. 15.8%, respectively, $p = 0.00535$) (Figure 2).

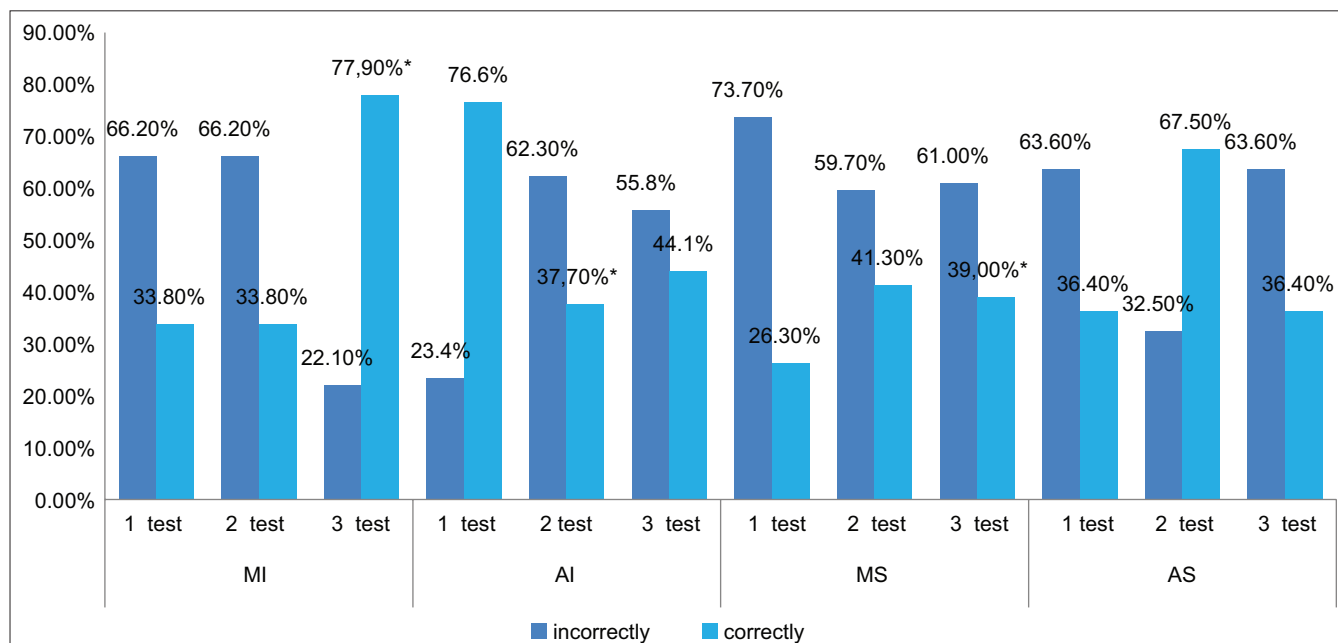


Figure 1: The percentage of correct and incorrect answers of students in one test (with informing about the category), in two and three tests (without informing about the category) in a 2 h training. *Statistically significant differences between the 1st and 3rd tests for MI (χ^2 McNemar 19.4, $ss = 1$, $p = 0.00001$), for AI (χ^2 McNemar 5.4 $ss = 1$, $p = 0.02064$), by MS (χ^2 McNemar 18.3 $ss = 1$, $p = 0.00002$), between two and three tests by AS (χ^2 McNemar 13.9, $ss = 1$, $p = 0.00019$). MI: Mitral insufficiency, AI: Aortic insufficiency, AS: Aortic valve stenosis, MS: Mitral valve stenosis

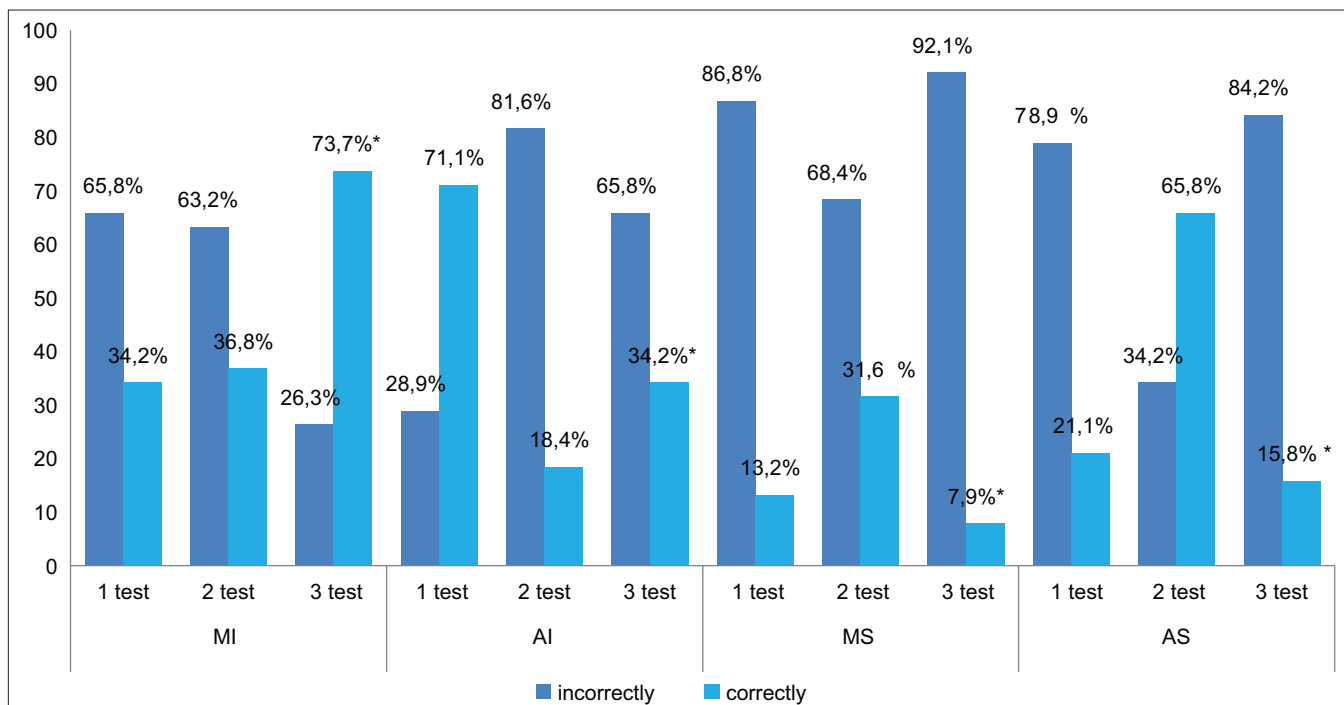


Figure 2: The percentage of correct and incorrect answers of students in the 1st test (with informing about the category), in the 2nd and 3rd tests (without informing about the category) in the 4 h training. *Statistically significant differences between the 1st and 3rd tests for MI (χ^2 McNemar 6.76, $ss = 1$, $p = 0.00933$), one and three tests for AI (χ^2 McNemar 10.62, $ss = 1$, $p = 0.00112$), two and three by the AS test (χ^2 McNemar 7.76, $ss = 1$, $p = 0.00535$). MI: Mitral insufficiency, AI: Aortic insufficiency, AS: Aortic valve stenosis, MS: Mitral valve stenosis

The highest average percentage of incorrect answers (82.4%) was established when students recognized the MS (Figure 2).

Comparison of the accuracy of diagnosis of defects among students in 2 h and 4 h trainings revealed statistically significant differences in χ^2 Pearson between the second tests for AI 37.6% versus 18.4% ($p = 0.036$), between the third tests for MS 38.9% versus 7.9% ($p = 0.00053$), according to AS 36.36% versus 15.79% ($p = 0.0229$).

Results of the repeating test after 6 months

Repeated testing in the 4th year in a real patient did not reveal statistically significant differences in the accuracy of diagnosis of MI in a real patient between the intervention group and the control group (35.0% vs. 30.8%, $p = 0.651$).

Discussion

In this study, we examined the effectiveness of training on auscultation of the heart using the KAF 990 cardiac simulator, aimed at acquiring auscultatory heart skills by medical students.

In general, acquiring heart auscultation skills are a difficult task. The gradual deterioration of the quality

of education is caused by: time limits, low availability of thematic patients, the severity of the patient's condition, the presence of psychological problems in students when working with a real patient, the direct refusal of patients to communicate with students [15].

We demonstrated that the rate of accuracy of auscultation of the heart decreased in the third test, which was closer to the clinical conditions than the first test. This was mainly due to the incorrect identification of AI, MS, and AI. These results suggest that one training in cardiac auscultation training using a patient's cardiac simulator may not be enough to acquire the competency necessary for a clinician and that medical students are less likely to correctly identify AI, MS, and AI even right after auscultation training.

The diagnostic accuracy of 45.9% in 2 h training and 35.3% in 4 h training in our study is not satisfactory. Diastolic murmurs, such as aortic regurgitation and mitral stenosis, are usually a problem for most students in the learning process [7], [16]. In our study, the accuracy of the correct diagnosis of mitral stenosis among all malformations was the lowest in the 4 h training, while the percentage of correct detection of MI was relatively better among students. There was no significant improvement in the diagnostic accuracy of the MS even after the intervention. The results of our study are consistent with the study of Birdane *et al.* (2012) and Binka *et al.* (2016), where students also better recognized systolic murmurs compared to diastolic murmurs [7], [17]. Physical examination has limited ability to evaluate diastolic murmurs, with a sensitivity of only 14–33% for the diagnosis of aortic

regurgitation [18], [19]. Modifications to the training will be required to teach auscultation of mitral stenosis noise.

An alternative to long-term repetition of cardiac auscultation in patients, which is undesirable and impossible, is the use of cardiovascular equipment. The using of simple cardiopulmonary simulators as tool of the medical education may be practical, cost effective, and efficient [2].

It is known that repeated intentional repetitive practice with constructive feedback and an increase in the time spent on the study of a simulated cardiac examination have a significant influence on the effectiveness of modeling [20], [21], [22]. This study found that 2 h training was more effective than 4 h training, repeated exposure to an expert assessment did not improve students' knowledge, as in the Swamy *et al.* study (2014) [23].

In the present study, it was found that the use of a simulator in cardiac auscultation training significantly increased the percentage of accurate detection of systolic murmur in MI immediately after training on a simulator (more than 73%). However, with repeated testing, regression was observed in the diagnostic accuracy of MI in the intervention group after 60 months of observation. It was revealed that the auscultation skills of students at the bedside of a real patient did not increase after training on the simulator: The accuracy of diagnosis of the auscultatory picture of the defect was equally low in the intervention group and the control group. Vukanovic-Criley *et al.* [11] reported that cardiac examination skills do not improve after the 3rd year of study at a medical school and may decline after several years in clinical practice. Therefore, it is extremely important for medical students to acquire competency to identify these abnormal heart sounds and sounds before participating in clinical practice [23].

Conclusion

Two hour training was more effective than 4 h training, repeated exposure to an expert assessment did not improve students' knowledge. After training on cardiac auscultation using a patient's cardiac simulator, the accuracy rate was low in a situation close to the clinical conditions and in a clinic on a real patient. This was mainly due to the low level of identification of MS, AI, and AS. One training session using a single cardiological patient simulator may not be enough for medical students to achieve the competency necessary for the clinician. We may have to consider this characteristic of medical students when we provide them with cardiac auscultation training. It is necessary to include modeling in preclinical modules, in particular, in the module of the cardiovascular system, as a mandatory component in

training. Training using a cardiopulmonary simulator can be a useful tool for training preclinical medical students, to help translate pre-clinical knowledge into real clinical skills. The results of our research can be a platform for well-planned large-scale studies to study real results after changing the curriculum. Future research should focus on comparing key features of educational design and determining the effectiveness of cardiosimulation.

Limitations

Our study is not without limitations. The design of this research was quasi-experimental. The selection of participants was carried out by a targeted sampling method, in which participants are selected on the basis of characteristics that will reliably answer of the research question; randomization and blinding were not carried out. The benefits of short simulation training were studied. Only an expert assessment of auscultation skills of students of one medical university was carried out. When conducting a controlled study on a real patient, the sample size was small; only one patient with one defect was tested.

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